

## The Claims

What is claimed is:

1. An abrasive free polishing formulation for removing at least a portion of a metal film, comprising an oxidizing agent and a corrosion inhibitor said formulation having a pH in a range of from about 0.1 to 6.9.
2. The abrasive free polishing formulation according to claim 1 wherein the oxidizing agent is an iodate salt.
3. The abrasive free polishing formulation according to claim 1, wherein the oxidizing agent is selected from the group consisting of hydrogen peroxide, potassium iodate, ferric nitrate, ammonium chlorite, ammonium chlorate, ammonium iodate, ammonium perborate, ammonium perchlorate, ammonium periodate ammonium persulfate, tetramethylammonium chlorite, tetramethylammonium chlorate, tetramethylammonium iodate, tetramethylammonium perborate, tetramethylammonium perchlorate, tetramethylammonium periodate, tetramethylammonium persulfate, urea hydrogen peroxide, 4-methylmorpholine *N*-oxide, and pyridine *N*-oxide.
4. The abrasive free polishing formulation according to claim 1, wherein the corrosion inhibitor is a carboxylic acid.
5. The abrasive free polishing formulation according to claim 1, wherein the corrosion inhibitor is selected from the group consisting of glycine, oxalic acid, malonic acid, succinic acid, citric acid and nitrilotriacetic glycine, oxalic acid, malonic acid, succinic acid, citric acid, and nitrilotriacetic acid.
6. The abrasive free polishing formulation according to claim 1, wherein the corrosion inhibitor is a dicarboxylic acid.
7. The abrasive free polishing formulation according to claim 6, wherein the dicarboxylic acid has a nitrogen containing functional group.
8. The method according to claim 6, wherein the dicarboxylic acid is iminodiacetic acid.

9. The abrasive free polishing formulation according to claim 1, wherein the corrosion inhibitor is iminodiacetic acid.
10. The abrasive free polishing formulation according to claim 1, wherein the metal film comprises copper, a copper alloy or a copper compound having copper as its principal component.
11. The abrasive free polishing formulation according to claim 1, wherein the metal film comprises aluminum, an aluminum alloy or an aluminum compound having aluminum as its principal component.
12. The abrasive free polishing formulation according to claim 1, wherein the metal film comprises tungsten, a tungsten alloy or a tungsten compound having tungsten as its principal component.
13. The abrasive free polishing formulation according to claim 12, wherein the tungsten compound is a tungsten nitride, tantalum, tantalum nitride, silicon doped tantalum nitride, titanium nitride and silicon doped titanium nitride
14. The abrasive free polishing formulation according to claim 1, wherein the metal film is selected from the group consisting of titanium, a titanium alloy, or a titanium compound having titanium as its principal component.
15. The abrasive free polishing formulation according to claim 14, wherein the titanium compound is selected from the group consisting of titanium nitride and silicon doped titanium nitride.
16. The abrasive free polishing formulation according to claim 1, wherein the metal film is selected from the group consisting of tantalum, a tantalum alloy or a tantalum compound having tantalum as its principal component.

17. The abrasive free polishing formulation according to claim 16, wherein the tantalum compound is selected from the group consisting of tantalum nitride and silicon doped tantalum nitride.
18. The abrasive free polishing formulation according to claim 1, further comprising an activating agent.
19. The abrasive free polishing formulation according to claim 18, wherein the activating agent is selected from the group consisting of inorganic and organic acids.
20. The abrasive free polishing formulation according to claim 19, wherein the inorganic acid is selected from the group consisting of phosphoric acid, fluoroboric acid, and iodic acid.
21. The abrasive free polishing formulation according to claim 19, wherein the organic acid is selected from the group consisting of citric acid, malic acid,
22. The abrasive free polishing formulation according to claim 1, further comprising a pH modifier in such amounts to modify the pH to a region of about 0.1 to 6.9, wherein said pH modifier is selected from the group consisting of: potassium hydroxide, sodium hydroxide, ammonium hydroxide, tetramethylammonium hydroxide, or quaternary ammonium hydroxide.
23. The abrasive free polishing formulation according to claim 1, further comprising a cleaning agent.
24. The abrasive free polishing formulation according to claim 23, wherein the cleaning agent is a carboxylic acid.
25. The abrasive free polishing formulation according to claim 24, wherein the cleaning agent is selected from the group consisting of glycine, oxalic acid, malonic acid, succinic acid, citric acid and nitrilotriacetic acid.
26. The abrasive free polishing formulation according to claim 23, wherein the cleaning agent is a dicarboxylic acid.

27. The abrasive free polishing formulation according to claim 26, wherein the dicarboxylic acid has a nitrogen containing functional group.
28. The abrasive free polishing formulation according to claim 26, wherein the dicarboxylic acid is iminodiacetic acid.
29. An abrasive free polishing formulation comprising an oxidizing agent, a corrosion inhibitor, activating agent and a cleaning agent.
30. The abrasive free polishing formulation according to claim 30 comprising the composition:
  - a. Oxidizing agent 0.1 to 20 % by weight
  - b. Corrosion inhibitor 0 to 5 % by weight
  - c. Activating agent 0 to 5 % by weight
  - d. Cleaning agent 0 to 5 % by weight
31. The abrasive free polishing slurry according to claim 30 further comprising water.
32. The abrasive free polishing slurry according to claim 30, further comprising a pH modifier in such amounts as to modify the pH to a region of about 0.1 to 6.9, wherein said pH modifier is selected from the group consisting of: potassium hydroxide, sodium hydroxide, ammonium hydroxide, tetramethylammonium hydroxide, or quaternary ammonium hydroxide
33. The abrasive free polishing formulation according to claim 30, wherein the cleaning agent is an inorganic acid.
34. The abrasive free polishing formulation according to claim 30, wherein the corrosion inhibitor is iminodiacetic acid.
35. The abrasive free polishing formulation according to claim 30, comprising the composition:
  - a.  $\text{HIO}_3$  4 % by weight

- b. IDA                      0.2 % by weight
- c.  $\text{H}_3\text{PO}_4$                 0.75 % by weight
- d. KOH                     1.73 % by weight
- e. Water                    balance

36. The abrasive free polishing formulation according to claim 30, wherein the pH of the polishing formula is in the range of from about 0.1 to 6.9.
37. The abrasive free polishing formulation according to claim 30, wherein the pH of the polishing formula is about 3.5.
38. The polishing formulation according to claim 30, wherein the oxidizing agent is selected from the group consisting of: hydrogen peroxide, potassium iodate, ferric nitrate, ammonium chlorite, ammonium chlorate, ammonium iodate, ammonium perborate, ammonium perchlorate, ammonium periodate ammonium persulfate, tetramethylammonium chlorite, tetramethylammonium chlorate, tetramethylammonium iodate, tetramethylammonium perborate, tetramethylammonium perchlorate, tetramethylammonium periodate, tetramethylammonium persulfate, urea hydrogen peroxide, 4-methylmorpholine *N*-oxide ( $\text{C}_5\text{H}_{11}\text{NO}_2$ ) and pyridine *N*-oxide ( $\text{C}_5\text{H}_5\text{NO}$ ).
39. A polishing method for removing at least a portion of a metal film, comprising mechanically rubbing a metal film surface using a chemical mechanical polishing formulation comprising an oxidizing agent and a corrosion inhibitor said formulation having a pH in the range of from about 0.1 to 6.9.
40. The polishing method according to claim 39, wherein the oxidizing agent is an iodate salt.
41. The polishing method according to claim 39, wherein the oxidizing agent is selected from the group consisting of hydrogen peroxide, potassium iodate, ferric nitrate, ammonium chlorite, ammonium chlorate, ammonium iodate, ammonium perborate, ammonium perchlorate, ammonium periodate ammonium persulfate, tetramethylammonium chlorite, tetramethylammonium chlorate, tetramethylammonium iodate, tetramethylammonium

perborate, tetramethylammonium perchlorate, tetramethylammonium periodate, tetramethylammonium persulfate, urea hydrogen peroxide, 4-methylmorpholine *N*-oxide (C<sub>5</sub>H<sub>11</sub>NO<sub>2</sub>) and pyridine *N*-oxide (C<sub>5</sub>H<sub>5</sub>NO).

42. The polishing method according to claim 39, wherein the corrosion inhibitor is a carboxylic acid.
43. The polishing method according to claim 39, wherein the corrosion inhibitor is selected from the group consisting of glycine, oxalic acid, malonic acid, succinic acid and nitrilotriacetic acid.
44. The polishing method according to claim 39, wherein the corrosion inhibitor is a dicarboxylic acid.
45. The polishing method according to claim 44, wherein the dicarboxylic acid has a nitrogen containing functional group.
46. The polishing method according to claim 44, wherein the dicarboxylic acid is iminodiacetic acid.
47. The polishing method according to claim 46, wherein the dicarboxylic acid is iminodiacetic acid.
48. The polishing method according to claim 39, wherein the metal film comprises copper, a copper alloy or a copper compound having copper as its principal component.
49. The polishing method according to claim 39, wherein the metal film comprises aluminum, an aluminum alloy or an aluminum compound having aluminum as its principal component.
50. The polishing method according to claim 39, wherein the metal film comprises tungsten, a tungsten alloy or a tungsten compound having tungsten as its principal component.

51. The polishing method according to claim 50, wherein the tungsten compound is a tungsten nitride, tantalum, tantalum nitride, silicon doped tantalum nitride, titanium nitride and silicon doped titanium nitride
52. The polishing method according to claim 39, wherein the metal film is selected from the group consisting of titanium, a titanium alloy, or a titanium compound having titanium as its principal component.
53. The polishing method according to claim 52, wherein the titanium compound is selected from the group consisting of titanium nitride and silicon doped titanium nitride.
54. The polishing method according to claim 39, wherein the metal film is selected tantalum, a tantalum alloy or a tantalum compound having tantalum as its principal component.
55. The polishing method according to claim 54, wherein the tantalum compound is selected from the group consisting of tantalum nitride and silicon doped tantalum nitride.
56. The polishing method according to claim 39, wherein said formulation, further comprises an activating agent.
57. The polishing method according to claim 56, wherein the activating agent is selected from the group consisting of inorganic and organic acids.
58. The polishing method according to claim 57, wherein the inorganic acid is selected from the group consisting of phosphoric acid, fluoroboric acid, and iodic acid.
59. The polishing method according to claim 57, wherein the organic acid is selected from the group consisting of citric acid, malic acid,
60. The polishing method according to claim 39, further comprising a pH modifier in such amounts to modify the pH to a region of about 0.1 to 6.9, wherein said pH modifier is selected from the group consisting of: potassium hydroxide, sodium hydroxide, ammonium hydroxide, tetramethylammonium hydroxide, or quaternary ammonium hydroxide.

61. The polishing method according to claim 39, wherein said formulation further comprises a cleaning agent.
62. The polishing method according to claim 61, wherein the cleaning agent is a carboxylic acid.
63. The polishing method according to claim 61, wherein the cleaning agent is selected from the group consisting of glycine, oxalic acid, malonic acid, succinic acid, citric acid and nitrilotriacetic acid.
64. The polishing method according to claim 61, wherein the cleaning agent is a dicarboxylic acid.
65. The polishing method according to claim 64, wherein the dicarboxylic acid has a nitrogen containing functional group.
66. The polishing method according to claim 65, wherein the dicarboxylic acid is iminodiacetic acid.
67. The polishing method according to claim 39, wherein said formulation further comprises an activating agent and a cleaning agent.
68. The polishing method according to claim 67, wherein said formulation comprises:
  - a. Oxidizer 0.1 to 20 % by weight
  - b. Corrosion inhibitor 0 to 5 % by weight
  - c. Activating agent 0 to 5 % by weight
  - d. Cleaning agent 0 to 5 % by weight
69. The polishing method according to claim 68, further comprising a pH modifier in such amounts to modify the pH to a region of about 0.1 to 6.9, wherein said pH modifier is selected from the group consisting of: potassium hydroxide, sodium hydroxide,



ammonium hydroxide, tetramethylammonium hydroxide, or quaternary ammonium hydroxide.

70. The polishing method according to claim 68, wherein the cleaning agent is an inorganic acid.

71. The polishing method according to claim 68, wherein the corrosion inhibitor is iminodiacetic acid.

72. The polishing method according to claim 39, wherein the formulation comprises:

- |                            |                  |
|----------------------------|------------------|
| a. $\text{HIO}_3$          | 4 % by weight    |
| b. IDA                     | 0.2 % by weight  |
| c. $\text{H}_3\text{PO}_4$ | 0.75 % by weight |
| d. KOH                     | 1.73 % by weight |
| e. Water                   | balance          |

73. The polishing method according to claim 72, wherein the pH of the formulation is in the range of from about 0.1 to 6.9.

74. The abrasive free polishing formulation according to claim 72, wherein the pH of the formulation is about 3.5.

75. The polishing method according to claim 68, wherein the oxidizing agent is selected from the group consisting of: hydrogen peroxide, potassium iodate, ferric nitrate, ammonium chlorite, ammonium chlorate, ammonium iodate, ammonium perborate, ammonium perchlorate, ammonium periodate ammonium persulfate, tetramethylammonium chlorite, tetramethylammonium chlorate, tetramethylammonium iodate, tetramethylammonium perborate, tetramethylammonium perchlorate, tetramethylammonium periodate, tetramethylammonium persulfate, urea hydrogen peroxide, 4-methylmorpholine *N*-oxide ( $\text{C}_5\text{H}_{11}\text{NO}_2$ ) and pyridine *N*-oxide ( $\text{C}_5\text{H}_5\text{NO}$ ).